PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 108030-5PCT

Box No. I TITLE OF INVENTION

UV LED BASED WATER PURIFICATION MODULE FOR INTERMITTANTLY OPERABLE FLOW-THROUGH HYDRATION SYSTEM

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

HYDRO-PHOTON, INC.
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United States of America

Telephone No.

Facsimile No.

Teleprinter No.

Applicant's registration No. with the Office

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MAIDEN, Miles
Parker Point Road
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United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

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☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. V DESIGNATION OF STATES *Mark the applicable check-boxes below; at least one must be marked.*

The following designations are hereby made under Rule 4.9(a):

Regional Patent

☒ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZM** Zambia, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

☒ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **BG** Bulgaria, **CH & LI** Switzerland and Liechtenstein, **CY** Cyprus, **CZ** Czech Republic, **DE** Germany, **DK** Denmark, **EE** Estonia, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **HU** Hungary, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **RO** Romania, **SE** Sweden, **SI** Slovenia, **SK** Slovakia, **TR** Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GQ** Equatorial Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☒ **AE** United Arab Emirates .....
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☒ **CA** Canada
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☒ **KR** Republic of Korea .....
☒ **KZ** Kazakhstan .....
☒ **LC** Saint Lucia
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☒ **LS** Lesotho .....
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☒ **VN** Viet Nam .....
☒ **YU** Serbia and Montenegro .....
☒ **ZA** South Africa .....
☒ **ZM** Zambia
☒ **ZW** Zimbabwe .....

Check-boxes below reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ ..... ☐ ..... ☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Supplemental Box *If the Supplemental Box is not used, this sheet should not be included in the request.*

1. *If, in any of the Boxes, except Boxes Nos. VIII(i) to (v) for which a special continuation box is provided, **the space is insufficient** to furnish all the information: in such case, write "Continuation of Box No...." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*

   (i) ***if more than two persons are to be indicated as applicants and/or inventors** and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;*

   (ii) *if, in Box No. II or in any of the sub-boxes of Box No. III, the indication **"the States indicated in the Supplemental Box"** is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*

   (iii) *if, in Box No. II or in any of the sub-boxes of Box No. III, **the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America**: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*

   (iv) *if, in addition to the agent(s) indicated in Box No. IV, there are **further agents**: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*

   (v) *if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "**patent of addition**," or "**certificate of addition**," or if, in Box No. V, the name of the United States of America is accompanied by an indication "**continuation**" or "**continuation-in-part**": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*

   (vi) *if, in Box No. VI, there are **more than five earlier applications whose priority is claimed**: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.*

2. *If, with regard to the **precautionary designation statement** contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.*

CESARI, Robert A.
MCKENNA, John F.
O'DONNELL, Martin J.
O'KONSKI, Thomas C.
SHEEHAN, Patricia A.
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LOGINOV, William A.
REINEMANN, Michael R.
ROONEY, Rita M.
CAPONE, John L.
BADZINSKI, Michael E.
JOHNSTON, Sidney A.
PAUL, Edwin H.
RIGBY, Robert A.
DREGER, Duane H.

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item (1) (26.09.2002) 26 September 2002	60/413,884	US		
item (2) (10.10.2002) 10 October 2002	60/417,584	US		
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☒ item (1) ☒ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

* *Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* ....

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA / US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*: Number of declarations

☐ Box No. VIII (i)	Declaration as to the identity of the inventor	:
☐ Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	:
☐ Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	:
☐ Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)	:
☐ Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	:

Box No. IX CHECK LIST; LANGUAGE OF FILING

This international application **contains**:

(a) **in paper form**, the following number of sheets:

request (including declaration sheets)	:	5
description (excluding sequence listings and/or tables related thereto)	:	7
claims	:	6
abstract	:	1
drawings	:	7
Sub-total number of sheets	:	26
sequence listings	:	
tables related thereto	:	
(for both, actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (c) below)		
Total number of sheets	:	26

(b) ☐ **only in computer readable form** (Section 801(a)(i))
- (i) ☐ sequence listings
- (ii) ☐ tables related thereto

(c) ☐ **also in computer readable form** (Section 801(a)(ii))
- (i) ☐ sequence listings
- (ii) ☐ tables related thereto

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which are contained the
- ☐ sequence listings: .....
- ☐ tables related thereto: .....

(additional copies to be indicated under items 9(ii) and/or 10(ii), in right column)

This international application is **accompanied** by the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item)*:

	Number of items
1. ☒ fee calculation sheet	1
2. ☐ original separate power of attorney	
3. ☐ original general power of attorney	
4. ☐ copy of general power of attorney; reference number, if any:	
5. ☐ statement explaining lack of signature	
6. ☐ priority document(s) identified in Box No. VI as item(s):	
7. ☐ translation of international application into *(language)*:	
8. ☐ separate indications concerning deposited microorganism or other biological material	
9. ☐ sequence listings in computer readable form *(indicate type and number of carriers)*	
(i) ☐ copy submitted for the purposes of international search under Rule 13*ter* only (and not as part of the international application)	
(ii) ☐ *(only where check-box (b)(i) or (c)(i) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Rule 13*ter*	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listings mentioned in left column	
10. ☐ tables in computer readable form related to sequence listings *(indicate type and number of carriers)*	
(i) ☐ copy submitted for the purposes of international search under Section 802(b-*quater*) only (and not as part of the international application)	
(ii) ☐ *(only where check-box (b)(ii) or (c)(ii) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Section 802(b-*quater*)	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the tables mentioned in left column	
11. ☐ other *(specify)*:	

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Patricia A. Sheehan

Patricia A. Sheehan

For receiving Office use only

1. Date of actual receipt of the purported international application:

2. Drawings:
- ☐ received:
- ☐ not received:

3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:

4. Date of timely receipt of the required corrections under PCT Article 11(2):

5. International Searching Authority (if two or more are competent): ISA /

6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International Application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: 108030-5PCT

Applicant

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . 240 T

2. SEARCH FEE . . . . . 700 S

International search to be carried out by US

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where items (b) and/or (c) of Box No. IX apply, enter **Sub-total number of sheets**
Where items (b) and (c) of Box No. IX do not apply, enter **Total number of sheets** }

b1 first 30 sheets 476 b1

b2 _____ (number of sheets in excess of 30) x _____ (fee per sheet) = _____ b2

b3 additional component (only if sequence listings and/or tables related thereto are filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)):

400 x _____ (fee per sheet) = _____ b3

Add amounts entered at b1, b2 and b3 and enter total at B . . . . 476 B

Designation Fees

The international application contains ALL designations.

5 (number of designation fees payable *(maximum 5)*) x 104 (amount of designation fee) = 520 D

Add amounts entered at B and D and enter total at I . . . . . 996 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . 40 P

5. TOTAL FEES PAYABLE 1976USD

Add amounts entered at T, S, I and P, and enter total in the TOTAL box — TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☐ authorization to charge deposit account (see below) ☐ postal money order ☐ cash ☐ coupons

☒ cheque ☐ bank draft ☐ revenue stamps ☐ other *(specify):*

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT

(This mode of payment may not be available at all receiving Offices)

Receiving Office: RO/ US

☐ Authorization to charge the total fees indicated above.

☒ *(This check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* Authorization to charge any deficiency or credit any overpayment in the total fees indicated above.

☐ Authorization to charge the fee for priority document.

Deposit Account No.: 03-1237

Date: 24 September 2003

Name: Patricia A. Sheehan

Signature: Patricia A Sheehan

See Notes to the fee calculation sheet

UV LED BASED WATER PURIFICATION MODULE FOR INTERMITTANTLY OPERABLE FLOW-THROUGH HYDRATION SYSTEMS

FIELD OF THE INVENTION

The inventive system described herein uses ultraviolet ("UV") light emitting diode (LED) technology to disinfect drinking water in intermittently operated flow-through hydration systems, such as wearable bladder bags. In such systems, water generally flows intermittently and on-demand from a bladder bag, or other "reservoir," through a tube and out into the user's mouth or, alternately, a drinking vessel.

BACKGROUND OF THE INVENTION

Currently, most UV water treatment systems use low pressure cold cathode fluorescent (CCFL) mercury vapor lamps with a primary radiative emission of 254 nanometers (2,537 angstroms). This wavelength, which falls within the short wave UV-C band, is highly germicidal.

The CCFL UV lamps can be very effective in batch UV water purification systems, such as the system described in United States Patents 5,900,212 and 6,110,424. However, the CCLF lamps are not well suited for wearable hydration systems. The lamps and their thermally insulating sleeves must be made from high quality, optical grade quartz, and thus, the CCFL UV lamp assemblies tend to be both costly and fragile. In addition, the CCFL UV lamps require high voltage AC power, and the circuitry needed to deliver this power is complex and relatively expensive, particularly if the input is from a DC source such as a battery.

The lamps also require a significant "warm-up" period during which lamp output "ramps up" from zero to full power. During this "ramp-up" period, any water flowing past a CCFL UV lamp will not have predictable or uniform UV exposure. As a result, the efficacy of the treatment of water in such a flow-through system, from a micro-biological standpoint, becomes unpredictable and unreliable. For this reason, safety dictates that CCFL UV lamps be allowed to "ramp-up" to a steady- state output

before water flow past the lamp is permitted. Achieving this steady-state output may take up to several minutes.

In a wearable flow-through hydration system or other intermittently operated on-demand flow-through systems, water consumption is not only intermittent but sudden and unpredictable. Accordingly, the CCFL UV lamps must, for safe operation, have been "ramped-up" to a steady state output before the water is allowed to flow past. The user must thus either keep the CCFL UV lamp on all the time or turn on the lamp for up to several minutes prior to each use, in order to allow for the "ramp-up" to steady state output. Neither of these scenarios is particularly desirable. In the first, the lamp must be kept on all the time and consumption of limited battery power quickly becomes a problem. In the second, the lamp must be turned on minutes before taking each drink and there is an obvious inconvenience.

SUMMARY OF THE INVENTION

The invention is a wearable or portable intermittently operable hydration system in which a water purification module containing one or more solid state UV devices, such as UV LEDs, is positioned in the path of the flow of the hydrating fluid, such as water, from a container or reservoir through a tube or straw to a mouthpiece or other orifice. The purification module provides a path for the water past the one or more UV LEDs, which are turned on to subject the water to sufficient UV radiation to purify the water. The UV LEDs are "instant on" devices with essentially no ramp-up, and a sensor or switch situated in the flow path signals the UV LEDs to turn on whenever the user initiates water flow through the path.

The UV LEDs are DC devices, and thus, require simpler, lower cost drive and control circuitry, than is required to operate CCFL lamps. Further, the UV LEDs are solid state devices and are thus less fragile than the CCFL lamps. Accordingly, the UV LEDs are well suited for intermittently operated wearable or portable flow-through hydration devices, such as wearable bladders, user-carried or worn sports water bottles, and so forth.

The DC power for the UV LEDs may be supplied by batteries, fuel cells and/or by solar cells, that is, photovoltaic panels, and the batteries and fuel cells and/or capacitors may be charged by solar cells. Further, a backpack that holds the system

may be made from flexible photovoltaic material or material that supports or incorporates photovoltaic panels, and thus, provide power directly to the unit. Alternatively, the UV LEDs may be powered by windup or crank-type dynamos in addition to or in place of the batteries, cells and, in a black-out condition, grid power.

The purification module and associated water flow sensor may instead be positioned in a drinking straw, and thus, be used to purify water flowing through the straw from any type of water bottle, canteen and so forth, carried by the user. The purification module may additionally include a filter that removes sediment from the water. Alternatively, the purification module may be included in the tubing of a portable water filtering system, such as a pump system used by campers. The filter in such a system may then be relatively coarse, since the filter needs only to trap sediment and not microbes, which are destroyed by the purification module. Further, such a filtering system would not require use of chemicals. In addition, the pump action may be harnessed to power the UV LEDs, and batteries and the like may thus be eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention description below refers to the accompanying drawings, of which:

Fig. 1 is schematic representation of a wearable hydration system constructed in accordance with the current invention;

Figs. 2-4 depict in more detail a purification module included in the system of Fig. 1;

Fig. 5 is a schematic drawing of an alternative system that includes the purification module in a drinking straw;

Fig. 6 is a schematic drawing of a system in which the purification module is included in a bottle top;

Fig. 7 is a functional block diagram of a portable water filtration system constructed in accordance with the invention;

Fig. 8 is a functional block diagram that depicts in more detail a power supply that may be included in the system of Fig. 1; and

Fig. 9 is a schematic drawing of an alternative to the system depicted in Fig. 1.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

As shown in Fig. 1, a wearable flow-through hydration system 10 includes a bladder 12 that is contained in a backpack 14. The bladder supplies hydrating fluids, such as water, to a user through a tube 16 and mouthpiece 18. The tube includes a purification module 22 that ensures that the water is sufficiently irradiated by ultraviolet ("UV") light in the germicidal range. As the water flows through the module 22, the UV radiation destroys the DNA of the microbes present in the water, thereby preventing microbial reproduction, and therefore, infection. The purification module 22 is discussed in more detail below with reference to Figs. 2-4

When a user requires water from the bladder 12, the water is drawn out of the bladder and flows past a water flow sensor 20. When the water flow sensor senses the flow, the sensor switches on the purification module 22. A power supply 24 supplies between 6 and 9 volts DC power to the purification module, and as discussed in more detail below, one or more solid state UV device, such as, UV light emitting diodes ("LEDs"), turn on to irradiate the water as the water flows through the purification module.

Referring now to Figs. 2-4, the purification module 22 includes an LED unit 30 that preferably contains a plurality of UV LEDs (not shown individually). The module 22 is positioned in the tube 16 such that water flows on paths 23a and 23b largely surrounding the unit 30. The dimensions of the purification module 22 and the associated section of the tube 16 are such that water flowing past and at a maximum distance away from the UV LEDs receives energy of at least $25mJ/cm^2$.

As shown in the drawings, the module 22 is widened where the LED unit 30 resides, such that water flow is not impeded by having to flow around, that is, on the paths 23a and 23b on either side of, the LED unit. This prevents a backing up or other interruption of the water flow through the tube 16 to the user.

Unlike CCFL UV lamps, UV LEDs are "instant on" devices meaning that UV output reaches steady state in micro or nanoseconds. Also, unlike fragile CCFL UV lamps, UV LEDs are robust solid state devices which do not require low pressure gas mixtures that can leak and fail. In addition, UV LEDs are DC devices which require

simple, low cost drive and control circuitry, as compared with the much more expensive and involved high voltage ballast circuitry of CCFL lamps.

In a wearable flow-through hydration system, where water is drawn periodically and unpredictably, UV LED based purification has a further advantage over CCFL UV systems. With "instant on" and no need for a "ramp-up" period, and thus, the LEDs can be activated only as needed, i.e., while water is being drawn. When water is not being drawn, the LEDs are off and no power is consumed.

A "drinking straw" embodiment of the invention is shown in Fig. 5. A flow-through purification module 32 is connected in line between the mouthpiece 33 and the tailpiece 34 of a drinking straw generally indicated at 35. The module is of the same construction as the module 22 of Figs. 1-4, with an attached power supply 36. A flow sensor 37 is disposed below the module 32. In the illustration the drinking straw has been inserted through the cover 38 of a container 40 containing a liquid such as water. The user imbibes the liquid as she would through a conventional drinking straw, with the "instant on" feature of the purifier module purifying the water on-demand as the water flows through the module.

In Fig. 6 a purification module 50 has been combined with a bottle top 52 that contains a power supply (not shown) in a cavity 52a. The upper end of the module 52 terminates in a "push-pull" valve 53 of the type often used by cyclists, hikers, etc. The lower end of the module, which extends into the bottle 54 to which the top 52 is attached, may carry an optional filter 56 for removal of particles entrained in the water entering the module 50. The sensor 58 may be eliminated, and the push-pull operation of the valve 53 may instead be used to control the turning on of the UV LEDs, with the pulling or opening of the valve turning on the purification module.

Fig. 7 depicts a purification module 60 in use in a portable water filtration system 62, such as those used by campers. The purification unit destroys microbes in the water that is pumped through the system via pump 64, while one or more filters 66 remove sediments from the water. The pump action may also provide power to the UV LEDs through the power supply 68, which operates in a known manner to convert pumping action to DC power. In such a filtration system, a water flow sensor is not required, since the power supply utilizes pumping action and thus does not provide power to the UV LEDs unless the pump is operated to draw water through the system.

The one or more filters need not be as fine as those used in conventional water filtration systems, since the filters need not trap the microbes, which are instead destroyed by the UV radiation. Further, the water filtration system does not require the chemicals used in conventional filtration systems.

The power supplies discussed above may include conventional batteries or solar cells, that is, photovotaic panels. Alternatively, the power supply may include batteries, fuel cells or capacitors that are charged by solar cells, and/or windup or crank-type dynamos. Further, the backpack 14 (Fig. 1) that holds the system may be made from flexible photovoltaic material or made of material that supports or incorporates the photovoltaic panels, and thus, provide power directly to the unit. Similarly, a carrier (not shown) for the bottle 54 (Fig. 6) may be made from, support or incorporate photovoltaic material. In addition or instead, the bottle top 52 may be made relatively inflexible photovoltaic material or support one or more photovoltaic panels. Alternatively, the UV LEDs may be powered by windup or crank-type dynamos (not shown) in addition to or in place of the batteries, cells and, in a black-out condition, grid power.

Referring now to Fig. 8, when solar cells are used, the power supply 80 preferably includes a current shunt 82 that is coupled to a microcontroller 84, for measuring the current supplied to the UV LEDs and calculating the UV dose, which is proportional to the current. When there are fluctuations in solar energy, such as when a cloud covers the sun, the microcontroller may impede the flow of the water, to provide longer periods of exposure to the UV radiation by controlling the amount by which a valve 86 opens to allow water flow past the UV LEDs in unit 88. The microcontroller may instead prevent the water from flowing through the purification module until sufficient current can be supplied. As appropriate, the unit may be switched from, for example, solar power to backup battery power at appropriate times by the microcontroller and/or the user.

As depicted in Fig. 9, the LED unit 22 may instead be positioned in the narrowing channel 13 that connects the bladder 12 to the tubing 16, with the UV LEDs turning on when water flows through the channel. Alternatively or in addition, UV LEDs 90 may be positioned facing inwardly in the walls 92 of the bladder or in the area proximate to the channel 13 to supply UV radiation to the water held in the bladder.

The UV LEDs in the walls may, for example, be turned on when associated solar cells have stored sufficient energy, as a precaution against changing environmental conditions that might otherwise disrupt the power to the UV LEDs. As appropriate, the treated water may then flow through the purification module as discussed above and be subject to further UV radiation, assuming the solar cells are sufficiently charged. Alternatively, the water may be diverted around the unit or flow through the unit without further treatment. A similar arrangement and operation of the wall-mounted UV LEDs may be used in the water bottle 54 depicted in Fig.6.

In the embodiments described above, the water flow sensors may be replaced with user-activated switches that a user turns on to activate the UV LEDs in the LED unit 30 when, for example, the user desires to take a drink. Further, automatic or user-activated switches may be included to actuate the UV LEDs 90 in the walls of the containers at desired times, such as when sufficient solar power is available or it is convenient for the user to operate a dynamo, and so forth.

In summary, the UV LED purification system described above has numerous advantages. The UV LED purification system is less costly, more robust, less complicated, more convenient, and less power-consuming. It also has the potential to be smaller and lighter than CCFL technology. Further, the UV LED purification system is particularly well suited for intermittent on-demand use. Accordingly, the system is well suited for use in wearable or portable hydration devices.

What is claimed is:

CLAIMS

1. A wearable hydration system including:

a bladder for holding a hydrating fluid;

tubing for providing a path for the hydrating fluid from the bladder;

a sensor for signaling when the hydrating fluid is flowing from the bladder;

a purification module including one or more solid state UV devices that are positioned in the tubing to provide UV radiation in a germicidal range to purify the flowing fluid, the UV devices turning on when the sensor indicates that fluid is flowing from the bladder and turning off when the sensor indicates that fluid is not flowing from the bladder; and

a wearable pack for holding at least the bladder.

2. The wearable hydration system of claim 1 further including a power supply that provides power to the purification module.

3. The wearable hydration system of claim 2 wherein the power supply includes solar cells.

4. The wearable hydration system of claim 2 wherein the power supply includes one or more of batteries, fuel cells, capacitors, solar cells, and windup or crank-type dynamos.

5. The wearable hydration system of claim 4 wherein the power supply includes solar cells that charge one or more of the batteries, fuel cells and capacitors.

6. The wearable hydration system of claim 1 wherein the wearable pack is made of photovoltaic material and the pack supplies power to the UV devices.

7. The wearable hydration system of claim 4 wherein the wearable pack is made of photovoltaic material and supplies power to charge one or more of the batteries, fuel cells, solar cells and capacitors.

8. The wearable hydration system of claim 1 wherein the path through the purification module includes a wider section to allow water to flow unimpeded past the UV devices.

9. The wearable hydration system of claim 8 wherein the path provided through the purification module is sized to provide UV radiation of at least 25 mJ/cm^2 to all of the water flowing past the UV devices.

10. The wearable hydration system of claim 1 wherein the bladder is integral with the wearable pack.

11. The wearable hydration system of claim 1 further including one or more filters to remove sediments from the fluid.

12. The wearable hydration system of claim 1 further including a plurality of solid state UV devices mounted in walls of the bladder.

13. The wearable hydration system of claim 12 further including a user-activated switch to turn on the wall-mounted UV devices.

14. The wearable hydration system of claim 12 further including a switch that turns on the wall-mounted UV devices when the power supply has sufficient power.

15. A purification module for use with a wearable or portable hydrating fluid container, the water purification system including

tubing for providing a path for the hydrating fluid from the container;

means for signaling when water is flowing through the tubing from the container;

ABSTRACT OF THE DISCLOSURE

A wearable or portable intermittently operable hydration system includes a purification module that contains one or more solid state UV devices that are positioned in the path of hydrating fluid, or water, flow through the hydration system to a mouthpiece or other orifice. The purification module provides a path for the fluid past one or more solid state UV devices, such as UV LEDs, that produce UV radiation in a germicidal range. When the fluid is flowing past the UV LEDs, the LEDs are turned on to provide sufficient UV radiation to purify the water. The UV LEDs are instant on devices with essentially no ramp-up required, and a sensor or other signaling means in the flow path controls the turning on of the UV LEDs whenever the user initiates the fluid flow. The fluid flow path may run from a bladder in a backpack worn by the user, a sports bottle worn by or carried by the user or may be through a water filtration system that a user operates via a pump. The power for the purification module may come from batteries, solar cells, fuel cells, power converted from pumping or winding action or any combination thereof. Further, UV LEDs may be included in the walls of the container as additional or alternative sources of UV radiation. The UV LEDs in the walls of the container may then be turned on when sufficient energy is available, as a precaution against, for example, a change in environmental conditions.